Design & Fabrication of Self-Guided Smart Chair System for Library Book Access

Yogesh Mangaonkar
M. Tech. Student
Department of Mechanical Engineering
AGPCE, Nagpur, Maharashtra, India

Prof. R. R. Gandhe
Assistant Professor
Department of Mechanical Engineering
AGPCE, Nagpur, Maharashtra, India

Abstract

A library is a collection of sources of information. It is necessary to provide comfort to access a book specially while selecting books from shelf. So in order to access book comfortably from shelf at height up to 5 ft and more, an innovative idea of auto guided smart chair system has implemented. Main motive behind this concept is to allow person to sit on chair and operate it, which will be auto guided and same chair, will get lift to access books from a heighted shelf. Some ergonomic points are also considered to design chair. This paper discusses design and fabrication of smart library chair which will lift at a particular height. The operation of lifting and revolving of chair will done by pneumatic system and the base platform provided with wheels will get turn and move by a battery operated system through DC gear motor. This concept is more beneficial for a handicapped person.
Keywords: Pneumatic System, Library Book Access, Battery Operated, Self-Guided, Human Comfort, DC Gear Motor

I. INTRODUCTION

A library is a collection of sources of information and similar resources, made accessible to a defined community for reference or borrowing. It provides physical or digital access to material, and may be a physical building or room, or a virtual space, or both. Libraries range in size from a few shelves of books to several million items. A library is organized for use and maintained by a public body, an institution, a corporation, or a private individual. Public and institutional collections and services may be intended for use by people who choose not to or cannot afford to purchase an extensive collection themselves, who need material no individual can reasonably be expected to have, or who require professional assistance with their research.

There are lots of benefits to automate library. In spite of the challenges automation brings, its benefits quite outweigh its disadvantages. Library automation comes with a lot of benefits to both the users and the librarians who man the libraries. All automations had done related to data accessing and managing related books. In this project design and fabrication of self-guided smart chair system is done which is operated by user to access book. There are lots of issues while taking out books from heighted shelves. Hereby, to overcome this issue present work implementing a new system which will be pneumatic based. The main concept behind this is to access book from heighted shelves by auto guided chair system which is having driving and lifting facilities.

There are three methods for transmitting power from one point to another. Mechanical transmission is through shafts, gears, chains, belts, etc. Electrical transmission is through wires, transformers, etc. Fluid power is through liquids or gas in a confined space, Pneumatic system and Hydraulic system.

In this project pneumatic system is used which is part of fluid power. These two branches of fluid power are very different in behavior and performance, and hence are treated separately. Often the two branches are used in conjunction with each other, but unless the basic laws are studied separately, the result could be misleading.

II. LITERATURE REVIEW

A. *Yunxu Shi, Xiaoning Li and Yan Teng[1]*

The air with certain pressure in a pneumatic cylinder is usually exhausted into the atmosphere after work process. It is of significant that the air energy can be saved and re-used. In this paper, the constitution of an exhausted-air reclaiming system for pneumatic cylinders is studied. To find the possible influence on the cylinder work process, the effect of the system on the cylinder velocity characteristics is also researched and different control switch points are tested. Experimental results show that attaching a reclaiming device would not cause bad influence on the velocity stability if the switch point could be properly controlled. The effect of the system on the cylinder velocity characteristics and the control method are also researched through experiments. Experimental results show that attachment of a reclaiming device would not cause bad influence on the velocity stability but would increase the piston motion time under the same load condition.

All rights reserved by *www.ijirst.org*

B. Herman Miller[2]

Herman Miller has adopted the idea that there should only be effective works chairs, not chairs specifically designed for the executive of the office or a lesser chair for the secretary. All well practiced and hardworking employees. Herman Miller solves problems with innovative, inventive, unique and fresh ideas. Exponential amounts of time are spent on research and testing. Through the years, Herman Miller has taken risks, learned from mistakes, and succeeds in creating designs that have changed the world. An ergonomically solves problems with innovative, inventive, unique and fresh ideas. Exponential amounts of time are spent on research and testing. Through the years, Herman Miller has taken risks, learned from mistakes, and succeeds in creating designs that have changed the world. An ergonomically designed chair, as a good chair is crucial to on-the-job comfort and productivity. He suggested key features for chair design like it should be Ergonomically good for the body, Mindful of the environment, Beautifully and simply designed, fitting in with various work environments, Curvilinear and nonintrusive, Posture fit supports the pelvic tilt, which then aligns the spinal area, Wide and contoured back keeps pressure off from the lower spinal area, Slope of the armrest achieves comfort, Waterfall seat edge keeps pressure off the thighs and achieves better circulation - Woven seat and back suspension material-Conforms to the body and cradles it - Even pressure keeps user cool and avoids sweat and heat build-up. Ergonomics is the science of “fitting the man to the machine”, or the adaptation of tasks and tools to fit the user. Ergonomics covers all aspects of a job from physical stress to environmental factors. Ergonomic design is the practice of creating workplaces, machines and tasks to match the capabilities and limitations of the human body. Ergonomic principles say that the chair should first fit the user, then fit the task and then allow for posture to change with varieties of activity. Fitting the man to the machine implementing ergonomics into the workplace helps to decrease daily discomfort and the risk of on the job injury, while simultaneously increasing productivity. Musculoskeletal Disorders (MSDs) are the injuries most commonly seen in the workplace. MSDs are caused by repetitive motion and stress, wearing and tearing on tendons and joints. In fact, these types of injuries account for 33% of all injuries and illnesses that make people miss work.

C. Ming-Hung Tsai, Chi-Neng Cheng, and Ming-Chang Shih[3]

The pneumatic control systems have played the important roles in the industrial automation equipments owing to the some advantages like low cost, clean of the working environments, easy in power transfer, and so on. In recent years, high accuracy and high speed systems are growing up rapidly, and are important in high-tech industry. However, the precise position control of a pneumatic cylinder is very difficult due to the compressibility of air, nonlinear behavior of the air flow rate through the servo valve, the friction force between the cylinder and the piston, and the stick slip effect at the low speed of the system. The traditionally pneumatic control systems are only controlled to carry out simple on-off position and speed control by using programmable logic controller. The high precision control cannot be reached through on off logic controller so that the modern control strategies are essential. This is mainly to study the precision performance of positioning to the vertical pneumatic cylinder under vertical loading. The friction force and the vertical loading have the great effect on the positioning accuracy. The hybrid fuzzy sliding mode controller with loading compensator is developed and implemented in the microcomputer to control the position of the vertical pneumatic cylinder under vertical loading in the study. Regarding the simulation of loading force, it can be accomplished by controlling the pressure of the load cylinder using pneumatic proportional valve. From the experimental results, one can make conclusions as; the positioning accuracy would be decreased owing to the dead-zone of the servo valve, friction force, and loading effect. From the experimental results, performance with or without loading effect is satisfactory.

III. IDENTIFIED GAPS IN LITERATURE

The aim of the project is to overcome the problems faced while collecting books from heighted shelves. To Design and fabricate such a model pneumatic system is used. Selection of pneumatic system compared to hydraulic system is suitable as exhaust air can reclaimed and available at cheap cost. Which is a problem discussed in library analysis literature and use of pneumatic system compared to hydraulic system. Make use of pneumatic system that is readily available and cheap. Also all ergonomics factors are considered while selection and fabrication of chair as problems discussed in literature.

IV. PROBLEM FORMULATION

Many problems observed in library out of which manually selection books from big heighted shelves required more effort and time consuming. Problems are face out when we take out the books from heighted shelves. To overcome this problem an innovative idea has implemented to prepare efficient and cost effective system which is nothing but self-guided smart chair system.

V. OBJECTIVE

- To design and fabricate self-guided smart chair system which will be easily operated by person within library to access book.
- To provide human comfort inside the library to access books from heighted shelves.
- To use of pneumatic system as air is easily available and cheap.

All rights reserved by *www.ijirst.org*

A. *Why Pneumatic Systems?*

Pneumatics deals with system operated with air or other gaseous media. Pneumatics is a branch of physics applied to technology that makes use of gas or pressurized air. Pneumatic systems used extensively in industry are commonly powered by compressed air or compressed inert gases. A centrally located and electrically powered compressor powers cylinders, air motors, and other pneumatic devices. A pneumatic system controlled through manual or automatic solenoid valves is selected when it provides a lower cost, more flexible, or safer alternative to electric and actuators.

Pneumatics offers a very clean system, suitable for food manufacturing processes and other processes which require no risk of contamination. Hydraulics is generally not used in these environments due to the risk of hydraulic oil leaks from faulty valves, seals or burst hoses. Pneumatics offer rapid movement of cylinders and have the great advantage of availability in very small sizes.

Why does pneumatics offer a higher operating speed of its components? This is mainly due to air compressor flow rates, air is very agile and can flow through pipes very quickly and easily with little resistance, while hydraulic oil is a viscous substance and requires more energy to move. Also in pneumatics, cylinders and valves can dump their compressed air straight to the atmosphere when they need to change direction or alter their state quickly, compared with hydraulics where the oil must be routed back to the reservoir. Pneumatics does not have the potential force that hydraulics has to offer.

The lifting or moving of heavy loads is not best suited to pneumatics. Hydraulics can smoothly lift and move loads because the hydraulic oil is not compressible, compared to air which can become jerky and spongy as the air pressure fluctuates with cylinder movement or load changes. In general a much larger pneumatic cylinder is needed to obtain the same force that a hydraulic ram can produce.

In terms of energy costs pneumatics is more costly than hydraulics; this is mainly due to the amount of energy lost through heat production while compressing air. As per requirement present work need light weight, low risk, minimum maintenance, Cheap and clean system as air is used which is easily available. So that present work has selected pneumatic system.

B. *Formulation of Present Work*

Present work has design and fabricates such type of self-guided smart library chair system which is operated by user within library to access book from shelf. Main motive behind this concept is to provide human comfort inside the library while selection of books by the use of pneumatic system that is readily available and cheap to prepare efficient and cost effective system. A library is a collection of sources of information. It is necessary to provide comfort to access a book specially while selecting books from heighted shelves. So in order to access book comfortably from shelf at height up to 5 ft. and more, an innovative idea of self-guided smart chair system has implemented. Main motive behind this concept is to allow person to sit on chair which will be self-guided and same chair can be lifted to access books from a heighted shelf. Some ergonomic points are also considered to select chair.

This project includes design and fabrication of smart library chair system which will get lifted to a particular height and rotate at an angle of 45 degree. The operation of lifting and revolving of chair will done by pneumatic system and the base platform provided with wheels, will turn and move system which is operated by a battery. This concept is more beneficial for a handicapped person. Maximum weight to be lifted by system is considered as 90 kg. Height to be lifted by self-guide smart chair system is considered as 5 ft. Self-guided smart chair system used in library to access the books from shelves.

So by keeping this in mind system will design and fabricated by considering following requirements.

- Weight of person which will use and lifted by system.
- Height to be lifted to access book from shelf.
- For lifting operation pneumatic system is considered.
- To drive the system wheel mechanism is used to drive.
- DC gear motor is used to drive the wheels.
- Battery is used to provide power to the system.

C. *Types of Component to be used in System*

Self-guided smart chair system consist of battery, DC gear motor, Base plate, double acting pneumatic cylinder, driving and driven wheel control valve, fittings and tubes.

D. *Component to be Design for System*

- Pneumatic cylinder.
- Base plate.

Factors considered for design are as follows.

1) *Pneumatic Cylinder Design Factors*

- Actual operating Air pressure.
- Weight.
- Calculate the force.
- Bore diameter.

All rights reserved by *www.ijirst.org*

- Air Consumption rate.
- Account for internal friction.
- Plan for the future.

2) Base Plate Design Factors

- Load acting on base plate.
- Bending stress.
- Calculate bending stress.
- Maximum Deflection.

E. Selection of Wheels

Wheel Selection for this project is depends on following factors. There are many factors involved in selecting the proper wheel for an application.

- Wheel size.
- Wheel type.
- Load capacity.
- Ease of movement.
- Bearing type.
- Anticipated life.

Associated factors would involve the application itself.
Floor conditions should be taken into account:

- Type of floor.
- Foreign Material on the floor.
- Any extraordinary conditions.
- Such as water or chemicals
- Temperatures other than ambient Amount of usage.

F. Selection of DC Motor

Two DC gear motor is used for driving and control the direction of system. It is mounted on base plate. Chain drive is used to connect motor and wheel.

G. Component Details of Self-Guided Smart Chair System

1) Pneumatic Cylinder

Double acting pneumatic cylinder is mounted on center of base plate which will control upward and downward motion of chair. Also small double acting pneumatic cylinder is attached to the back of chair to perform turning operation of chair.

Fig. 1: Double Acting Pneumatic Cylinder

2) Base Plate

Base plate is main platform of system. Pneumatic cylinder is mounted on center of base plate. Battery and DC motor is also mounted on base plate. To drive the system drive wheel and idler wheel mechanism is attached with base plate.

Fig. 2: Base plate

3) Runner Drive Wheel and Idler Wheel

To drive the system wheels are selected as per required application. Present work uses two drive wheels of diameter 200 mm and two idler wheels of diameter 102 mm. By selecting rear wheels as drive with bigger diameter compare to front idler wheel smaller diameter proper balancing is obtained and speed obtained as per requirement. There are different size and materials

All rights reserved by *www.ijirst.org*

wheels are available which has been used with auto drive systems especially in robotics. In the present work rubber tired wheel is selected.

Fig. 3: Driving and idler wheels

4) Battery

12 volt battery is used to supply power to the DC motor system which will drive DC motor. It is fixed below the foot rest which is mounted on base plate.

Fig. 4: Battery

5) DC Gear Motor

Fig. 5: DC Gear Motor Arrangement

Two DC gear motor is used for driving and control the direction of system. It is mounted on base plate. Chain drive is used to connect motor and wheel. Both a chain drive and a belt drive are part of mechanisms that allow locomotion and a transfer of power within a particular piece of machinery. But present work have selected chain drive because the chain drive is a good choice since it is stronger because it is made of metal and lasts longer, more dependable to use, and easier to repair and less chances of slip. It is also easier to change gears in the instance when the chain is broken. However, its downside includes requiring lubrication to run smoothly and seamlessly, and the chain can be stuck in the links or can mangle itself while on the run. Simple chain drives usually contain two gears; the more complicated designs usually have two or more gears in the design. The additional gears are called “idle gears” and usually don’t contribute to the drive and its overall ratio. The only thing that impacts the gear ratio is the number of teeth in the first and last gear. Direction of system is controlled by keeping one motor off and other motor ON as per required direction. To move left side keep left motor OFF and right side motor ON which will operated by switch provided on chair hand.

To reduce or controlled speed of the DC gear motor present work have used voltage control method. Within library it is necessary to maintain speed.

6) Flow Control Valve, Pressure Gauge, Fittings And PU Tube and Switches

Flow control valve is used to maintain and control air supply and a pressure of air is measure and controlled by pressure gauge attached to air supply tubes.

Hand lever operated switch is used to control action of pneumatic system. Drive motor is operated by switch. All arrangement of switch and hand operated lever are located on both side of chair so user can operate it easily.

All rights reserved by *www.ijirst.org*


Hand lever operated switch


Fitting and valves

Fig. 6: Types of valves fittings and switched

VI. RESEARCH METHODOLOGY

A. Construction and Working of Self-Guided Smart Chair System

Self-guided smart chair system is operated by battery. Battery supplies power to the DC motor which is connected to the driving wheels through chain drive. There are two driving wheels and other two are driven. Both drive wheels are connected to DC gear motor thought chain drive. Forward and reversed motion is controlled by motor which is operated by switch provided on chair.

Direction of system is controlled by keeping one motor OFF and other motor ON as per required direction. To get direction on left side, keep left motor OFF and right side motor ON which will operated by switch provided on chair. The front two driven wheels can rotate in 360^0, which will follow the driving wheels and required direction can be achieved easily.

To reduce or controlled speed of the DC gear motor there is voltage control method. Chain drive is a part of mechanisms that allow locomotion and a transfer of power within a particular piece of machinery. It is also easier to change gears in the instance when the chain is broken. However, its downside includes requiring lubrication to run smoothly and seamlessly, and the chain can be stuck in the links or can mangle itself while on the run. Simple chain drives usually contain two gears; the more complicated designs usually have two or more gears in the design. The additional gears are called "idle gears" and usually don't contribute to the drive and its overall ratio. The only thing that impacts the gear ratio is the number of teeth in the first and last gear.

Double acting pneumatic cylinder having stroke of 600 mm is mounted vertically on the center of base plate. Piston end attached to the chair which will lift the chair and get operated by lever switch located on chair. Compressed air at pressure of 8 kg/cm2 is supplied to pneumatic cylinder through compressor which will be located outside library. Air receiver placed at safe location inside library in which air gets stored. This air supplied to the system through supply air tubes. Flow control valves will control the supply of air to the system.

Pneumatic cylinder having stroke 100 mm is used for turning operation of chair during lift. Through this user can turn chair at an angle of 45 degree both side. This small double pneumatic cylinder is attached on bottom side of chair pivoted on rod of main pneumatic cylinder. Chair is provided with foot rest and facility of side rack to hold book and front pad to place book. Ergonomic factors are considered while selecting and design chair system.

Self-guided smart chair system is designed to use within library. This system can be drive and operated by user within library which will cover height of 5.5 ft (1676.4 mm). User can easily access book from heighted shelves. This will be more beneficial for handicapped person. Weight carrying capacity of system is up to 70 kg and maximum up to 90 kg.


Fig. 7: Self-Guided Smart Chair System

All rights reserved by www.ijirst.org

B. Calculations

1) Design of Double Acting Pneumatic Cylinder for Lifting and Turning Chair Operation

Design factors to determine the right cylinder to fit their specific needs.

- Actual operating Air pressure.
- Weight.
- Calculate the force.
- Bore diameter.

Considerations for some Design parameter

- Air flow restrictions.
- Account for internal friction.
- Consider the angles.
- Plan for the future.

2) Pneumatic Cylinder Calculations for Lifting Application

Basic Considerations are
Pneumatic cylinder design pressure (P)(Average) = 0.5 Mpa .
Average weight of human body is 68 kg. But present work has considered here maximum weight of 90 kg.
Considered person weight (W) = 90 kg.
Factor of safety = 2.
Dead weight = 80 kg.
Pressure = Force/ Area
Force $(f_1) = (90 \times 2) + 80$
= 260 kg.
$= 260 \times 9.81$ (Specific gravity)
$f_1 = 2550.6$ N
Now,

$$\text{Area } (A_1) = (\pi / 4) \times D_1^2$$

Where,
(D_1= bore diameter of pneumatic cylinder used for lifting)
$0.5 = 2550.6 / (\pi / 4 \text{ x } D_1^2)$
$D_1 = 80.59$ mm.
As per SMC catalogue available diameter is 80 mm.
Selected Pneumatic cylinder bore diameter
$D_1 = 80$ mm
For 80 mm diameter standard stroke length available is 600 mm.
And maximum length stroke 1400 mm.
Selected Stroke length $L_1 = 600$ mm

3) Design of Double Acting Pneumatic Cylinder for Turning Chair Operation

Considerations
Pneumatic cylinder design pressure (P) = 0.5 Mpa.
Person weight (W) = 90 kg.
Factor of safety = 1.
Dead weight = 40 kg.
Pressure = Force/ Area
Force $(f_2) = (90 \times 1) + 40$
= 130 kg.
$=130\times 9.81$
$f_2 = 1275.3$ N.
Area $(A_2) = (\pi / 4) \times D_2^2$
Where,
(D_2= Cylinder bore diameter of pneumatic cylinder used for turning operation of chair.)
$0.5 = 1275.3 / (\pi / 4 \text{ x } D_2^2)$
D_2= 56.98 mm
As per catalogue available diameter is 32, 40 and 50 mm.
Selected Pneumatic cylinder bore diameter
D_2= 40 mm
For 40 mm diameter standard stroke length available is 100 mm
Selected stroke length,
$L_2 = 100$ mm

All rights reserved by *www.ijirst.org*

And maximum stroke length 800 mm.

4) Selected Pneumatic Cylinders are as Follows.

Bore Diameter (D1) = 80 mm

Stroke length (L_1) = 600 mm

(a) For Lifting

Bore Diameter (D_2) = 40 mm

Stroke length (L_2) = 100 mm

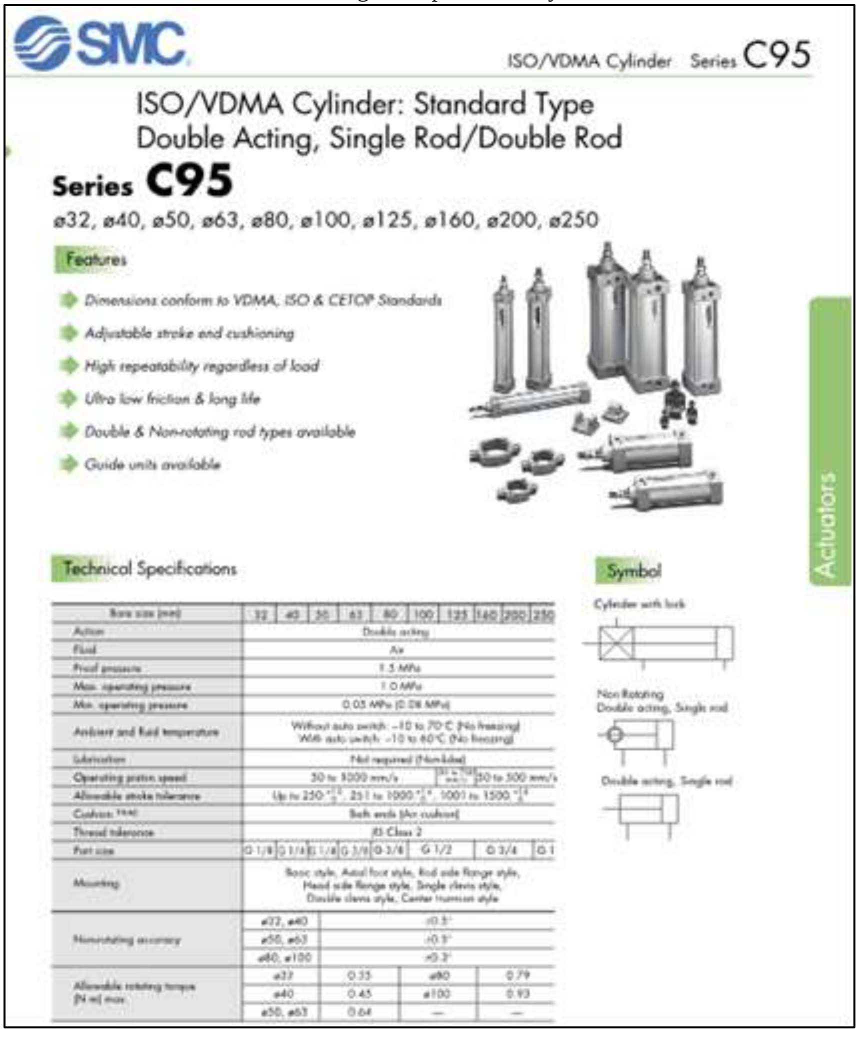
(b) For turning

Fig. 8: Selected double acting pneumatic cylinders

Standard catalogue of SMC for selection of double acting pneumatic cylinder is as shown below.

Table – 1

SMC catalogue for pneumatic cylinder



SMC ISO/VDMA Cylinder Series C95

ISO/VDMA Cylinder: Standard Type
Double Acting, Single Rod/Double Rod

Series C95

ø32, ø40, ø50, ø63, ø80, ø100, ø125, ø160, ø200, ø250

Features

- *Dimensions conform to VDMA, ISO & CETOP Standards*
- *Adjustable stroke and cushioning*
- *High repeatability regardless of load*
- *Ultra low friction & long life*
- *Double & Non-rotating rod types available*
- *Guide units available*

Actuators

Technical Specifications

Bore size (mm)	32	40	50	63	80	100	125	160	200	250
Action	Double acting									
Fluid	Air									
Proof pressure	1.5 MPa									
Max. operating pressure	1.0 MPa									
Min. operating pressure	0.05 MPa (0.08 MPa)									
Ambient and fluid temperature	Without auto switch: –10 to 70°C (No freezing) With auto switch: –10 to 60°C (No freezing)									
Lubrication	Not required (Non-lube)									
Operating piston speed	50 to 1000 mm/s							[illegible]	50 to 500 mm/s	
Allowable stroke tolerance	Up to 250 [illegible], 251 to 1000 [illegible], 1001 to 1500 [illegible]									
Cushion	Both ends (Air cushion)									
Thread tolerance	JIS Class 2									
Port size	G 1/8	G 1/4	G 1/4	G 3/8	G 3/8	G 1/2		G 3/4		G 1
Mounting	Basic style, Axial foot style, Rod side flange style, Head side flange style, Single clevis style, Double clevis style, Center trunnion style									

Non-rotating accuracy	ø32, ø40	±0.5°		
	ø50, ø63	±0.5°		
	ø80, ø100	±0.3°		
Allowable rotating torque (N·m) max.	ø32	0.35	ø80	0.79
	ø40	0.45	ø100	0.93
	ø50, ø63	0.64	—	—

Symbol

Cylinder with lock

Non Rotating Double acting, Single rod

Double acting, Single rod

All rights reserved by *www.ijirst.org*

Standard Stroke

Bore size (mm)	Standard stroke (mm)	Maximum manufacturable stroke
32	25, 50, 75, 100, 125, 150, 175, 200, 250, 300, 350, 400, 450, 500	700
40	25, 50, 75, 100, 125, 150, 175, 200, 250, 300, 350, 400, 450, 500	800
50	25, 50, 75, 100, 125, 150, 175, 200, 250, 300, 350, 400, 450, 500, 600	1200
63	25, 50, 75, 100, 125, 150, 175, 200, 250, 300, 350, 400, 450, 500, 600	1200
80	25, 50, 75, 100, 125, 150, 175, 200, 250, 300, 350, 400, 450, 500, 600, 700, 800	1400
100	25, 50, 75, 100, 125, 150, 175, 200, 250, 300, 350, 400, 450, 500, 600, 700, 800	1500

Note) Intermediate strokes are available, too. (Spacer is not used.)

C. *Base Plate Design*

Considerations -
Force (F) = 2550.6 N
Plate size = L 762 mm ×W 762 mm × T 14 mm
Moment of Inertia (I) = $bh^3/12$
= $(762 \times 14^3)/12$
I = 174244 mm^4
Section modulus (Z) = $bh^2/6$
= $(762 \times 14^2)/6$
Z = 24892 mm^4

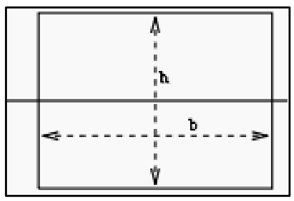


Fig. 8.1: Base Plate Design

Modulus of elasticity (E) = 210×10^3 N/mm^2
As in present work considered square base plate on the center of which pneumatic cylinder get mounted.
So that considering center point load first calculated shear force and bending moment.
Shear force calculations,
RA + RB = 2550.6 N
Moment at A,
2550.6 × 381 – RB × 762 = 0
RB = 1275.3 N
RA = 1275.3N

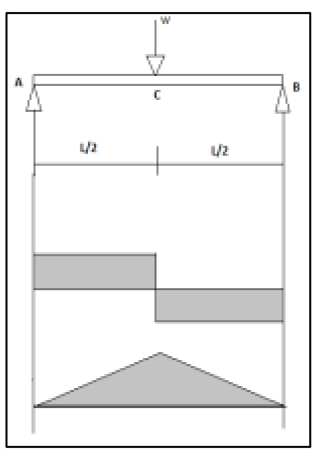


Fig. 9: SFD and BMD diagram

Shear force at A, B and C
SFA = 1275.3 N
SFC = RA – 2550.6 = 1275.3 N
SFB = 0
Now,

All rights reserved by www.ijirst.org

Bending moment calculations
Bending moment at A, C and B
BMA = 0
BMC = RA × 381 =1275.3 × 381 = 485775 N-mm.
BMB = 0
Calculate bending force,
Bending stress = M × Y/ I or
=Bending moment / Section modulus
= 485775 / 24892
= 19.51 N < 100 N/mm^2 (Design is safe).
Max. Deflection= $(W \times L^3) / (48 \times E \times I)$
= $(2550.6 \times 762^3) / (48 \times 210 \times 10^3 \times 174244)$
= 0.64 < 0.7 mm (L/1000) (Design is safe).
From above calculations
For plate length 762 mm × width 762 mm × thickness 14 mm all design calculations are safe.
So that present work has selected base plate of thickness 14 mm.
Size= L 762 mm × W 762 mm × T 14 mm

5) Selection of DC Gear Motor

MY1016Z2
Voltage = 24 Volt DC
Output = 250 Watt
RPM = 300
Full load current = 13.4A
No load Current = 2.2A
Torque Constant = 80kgcm
Torque stall = 240kgcm
Sprocket = 9Tooth only fits # 410 bicycle chains
For Chain Size = Pitch 0.5in
Roller Diameter = 0.3in
Roller Width = 0.16in

Fig. 10: DC Gear Motor

Fig. 11: Chain Drive Attachment

D. Wheel Selection

There are many factors involved in selecting the proper wheel for an application.
Among these are:

- Wheel size
- Wheel type
- Load capacity
- Ease of movement
- Bearing type

All rights reserved by www.ijirst.org

- Anticipated life

Associated factors would involve the application itself.
Floor conditions should be taken into account:

- Type of floor
- Foreign Material on the floor
- Any extraordinary conditions
- Such as water or chemicals
- Temperatures other than ambient
- Amount Of usage

In self guide smart chair system two drive wheel and two idler wheels are selected.

1) *Selected standard Driving Wheel of Diameter 200 mm*

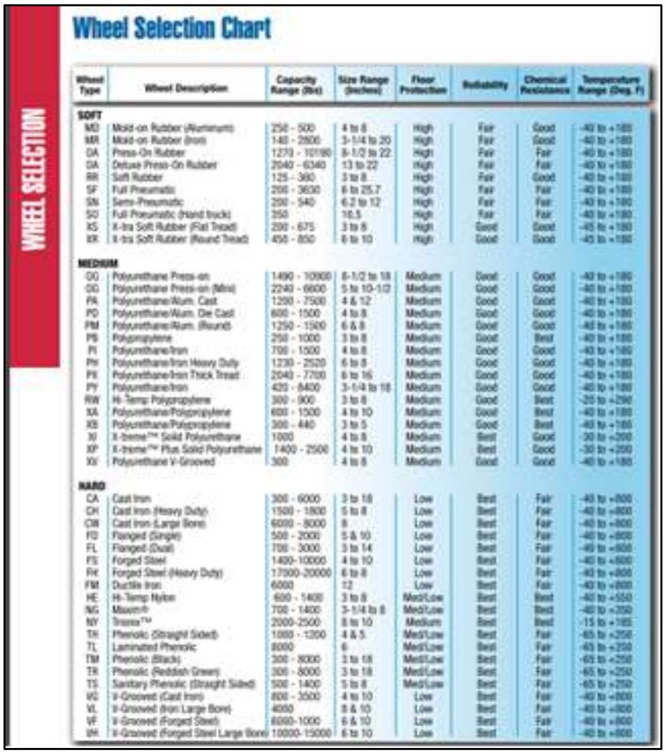
Fig. 12: Rubber driving wheel

2) *Selected Standard Idler Wheel of Diameter 102 mm*

Fig. 13: Idler wheel

Standard wheel selection chart are given as below

Table – 2
Wheel selection chart



WHEEL SELECTION

Wheel Selection Chart

Wheel Type	Wheel Description	Capacity Range (lbs)	Size Range (inches)	Floor Protection	Rollability	Chemical Resistance	Temperature Range (Deg. F)
SOFT							
MO	Mold-on Rubber (Aluminum)	250 - 500	4 to 8	High	Fair	Good	-40 to +180
MR	Mold-on Rubber (Iron)	140 - 2800	3-1/4 to 20	High	Fair	Good	-40 to +180
DA	Press-On Rubber	1270 - 10190	8-1/2 to 22	High	Fair	Fair	-40 to +180
DA	Deluxe Press-On Rubber	2040 - 6340	13 to 22	High	Fair	Fair	-40 to +180
RR	Soft Rubber	125 - 360	3 to 8	High	Fair	Good	-40 to +180
SF	Full Pneumatic	200 - 3630	6 to 25.7	High	Fair	Fair	-40 to +180
SN	Semi-Pneumatic	200 - 540	6.2 to 12	High	Fair	Fair	-40 to +180
SO	Full Pneumatic (Hand truck)	350	10.5	High	Fair	Fair	-40 to +180
XS	X-tra Soft Rubber (Flat Tread)	200 - 675	3 to 8	High	Good	Good	-45 to +180
XR	X-tra Soft Rubber (Round Tread)	450 - 850	6 to 10	High	Good	Good	-45 to +180
MEDIUM							
OG	Polyurethane Press-on	1490 - 10900	6-1/2 to 18	Medium	Good	Good	-40 to +180
OG	Polyurethane Press-on (Mini)	2240 - 6600	5 to 10-1/2	Medium	Good	Good	-40 to +180
PA	Polyurethane/Alum. Cast	1200 - 7500	4 & 12	Medium	Good	Good	-40 to +180
PD	Polyurethane/Alum. Die Cast	600 - 1500	4 to 8	Medium	Good	Good	-40 to +180
PM	Polyurethane/Alum. (Round)	1250 - 1500	6 & 8	Medium	Good	Good	-40 to +180
PS	Polypropylene	250 - 1000	3 to 8	Medium	Good	Best	-40 to +180
PI	Polyurethane/Iron	700 - 1500	4 to 8	Medium	Good	Good	-40 to +180
PH	Polyurethane/Iron Heavy Duty	1230 - 2520	6 to 8	Medium	Good	Good	-40 to +180
PK	Polyurethane/Iron Thick Tread	2040 - 7700	6 to 16	Medium	Good	Good	-40 to +180
PY	Polyurethane/Iron	420 - 8400	3-1/4 to 18	Medium	Good	Good	-40 to +180
RW	Hi-Temp Polypropylene	300 - 900	3 to 8	Medium	Good	Best	-20 to +250
XA	Polyurethane/Polypropylene	600 - 1500	4 to 10	Medium	Good	Best	-40 to +180
XB	Polyurethane/Polypropylene	300 - 440	3 to 5	Medium	Good	Best	-40 to +180
XI	X-treme™ Solid Polyurethane	1000	4 to 8	Medium	Best	Good	-30 to +200
XP	X-treme™ Plus Solid Polyurethane	1400 - 2500	4 to 10	Medium	Best	Good	-30 to +200
XV	Polyurethane V-Grooved	300	4 to 8	Medium	Good	Good	-40 to +180
HARD							
CA	Cast Iron	300 - 6000	3 to 18	Low	Best	Fair	-40 to +800
CH	Cast Iron (Heavy Duty)	1500 - 1800	5 to 8	Low	Best	Fair	-40 to +800
CW	Cast Iron (Large Bore)	6000 - 8000	8	Low	Best	Fair	-40 to +800
FD	Flanged (Single)	500 - 2000	5 & 10	Low	Best	Fair	-40 to +800
FL	Flanged (Dual)	700 - 3000	3 to 14	Low	Best	Fair	-40 to +800
FS	Forged Steel	1400-10000	4 to 10	Low	Best	Fair	-40 to +800
FH	Forged Steel (Heavy Duty)	17500-20000	6 to 8	Low	Best	Fair	-40 to +800
FM	Ductile Iron	6000	12	Low	Best	Fair	-40 to +800
HE	Hi-Temp Nylon	600 - 1400	3 to 8	Med/Low	Best	Best	-40 to +550
NG	Maxim®	700 - 1400	3-1/4 to 8	Med/Low	Best	Best	-40 to +250
NY	Trisma™	2000-2500	8 to 10	Medium	Best	Best	-15 to +185
TH	Phenolic (Straight Sided)	1000 - 1200	4 & 5	Med/Low	Best	Fair	-65 to +250
TL	Laminated Phenolic	8000	6	Med/Low	Best	Fair	-65 to +250
TM	Phenolic (Black)	300 - 8000	3 to 18	Med/Low	Best	Fair	-65 to +250
TR	Phenolic (Reddish Green)	300 - 8000	3 to 18	Med/Low	Best	Fair	-65 to +250
TS	Sanitary Phenolic (Straight Sided)	500 - 1400	5 to 8	Med/Low	Best	Fair	-65 to +250
VG	V-Grooved (Cast Iron)	800 - 3500	4 to 10	Low	Best	Fair	-40 to +800
VL	V-Grooved (Iron Large Bore)	4000	8 & 10	Low	Best	Fair	-40 to +800
VF	V-Grooved (Forged Steel)	6000-1000	6 & 10	Low	Best	Fair	-40 to +800
VH	V-Grooved (Forged Steel Large Bore)	10000-15000	6 to 10	Low	Best	Fair	-40 to +800

Details of wheel selection and its capacity range charts by RMW are also available.

All rights reserved by *www.ijirst.org*

E. Analysis of Results

Selected double acting pneumatic cylinder specifications for lifting operation are as follows.
Cylinder bore diameter (D_1) =80 mm.
Piston rod diameter (d_1) = 25 mm.
Length of stroke (L_1) = 600 mm.
Actual force (F_1) = 2550.6 N.
Actual Supplied pressure (P) = 8 kg/cm^2 or 0.8 mpa or 133.8 psi
A_1 = Area of piston/cylinder bore mm^2
a_1= Area of piston rod mm^2
Q_1 = Air flow rate.

1) Resulting values are as follows,

Area of cylinder bore/piston (A_1) = $(\pi/4) \times D_1^2 = (\pi/4) \times 80^2$ = 5026.54 mm^2 or 7.791 Inch^2
Pressure (P_1) = F_1/A_1= 2550.6/5026.54 = 0.51 N/mm^2 or mpa
Area of Piston rod (a_1) = $(\pi/4) \times d_2^2 = (\pi/4) \times 25^2$ = 490.87 mm^2 or 0.761 Inch^2
Pulling force (f_{p1}) = $P_1 \times (A_1\text{-}a_1)$ = 0.51 (5026.54-490.87) = 2313.19 N
Now, Air flow rate of each stroke Q is given by,

$$= \text{CFM (Cubic Feet per Minute)} = [(2 \text{ x } A_1\text{- } a_1) \text{ x } L_1 \text{ x } C] / 1728$$

Where,
A_1 = Piston Area (Square Inches) = 7.791 Inch^2
a_1= Rod Area (Square Inches) = 0.761 Inch^2
L_1 = Stroke (Inches) = 23.62 Inch
C = Cycles per Minute = 5 (Assumed).
CFM = [(2 × 7.791- 0.761) × 23.62 × 5] / 1728 = 1.01 ft3/min or 2.86 × 10^7 mm^3/min or 0.029 m^3/min.
Flow rate of each stroke Q_1 = 958050 mm^3/sec or 4.83 × 10^{-4} m^3/sec
Converting the flow rate from CFM (compressed air) to SCFM (free air) can be calculated as follows,

$$\text{SCFM} = \text{CFM} \times (P + 14.7) / 14.7$$

Where,
P = Supplied pressure in psi = 1.01 × (113.8 +14.7) / 14.7

$$\text{SCFM} = 8.83 \text{ ft}^3\text{/min (for free air)}$$

So, the consumption rate of a 80mm bore, 600 mm stroke cylinder operating 5 complete cycles per minute at supplied pressure 8 kg /cm^2 is 8.83 SCFM (Standard Cubic Feet Per Minute) of free air and 1.01 ft^3/min for compressed air.
Speed on the outward stroke = Q_1/A_1 = 476666.7/5026.54 = 94.82 mm/sec.
Speed of retraction = $Q_1 / (A_1\text{-}a_1)$ = 476666.7/4711.94 = 101.16 mm/sec.
Power = $P_1 \times Q_1 = 0.51\times10^6 \times 4.83 \times10^{-4}$ = 246.5 watts.

2) Selected double acting pneumatic cylinder specifications for turning chair operation are as follows.

Cylinder bore diameter (D_2) = 40 mm.
Piston rod diameter (d_2) = 15 mm.
Length of stroke (L_2) = 100 mm.
Actual force (F_2) = 1275.3 N
A_2 = Area of piston/cylinder bore mm^2
P = pressure in N/mm^2
a_2= Area of piston rod mm^2
Q_2 = Air flow rate.

3) Resulting values are as follows

Area of cylinder bore/piston (A_2) = $(\pi/4) \times D_2^2 = (\pi/4) \times 40^2$ = 1256.63 mm^2 or 1.95 Inch^2
Pressure (P_2) =F_2/A_2= 1275.3/1256.63 = 1.01 N/mm^2 or mpa
Area of Piston rod (a_2) = $(\pi/4) \times d_2^2 = (\pi/4) \times 15^2$ = 176.71 mm^2 or 0.27 Inch^2
Pulling force (f_{p2}) = $P_2 \times (A_2\text{-}a_2)$ = 1.01 (1256.63-176.71) = 1090.72 N
Now, Air flow rate of each stroke Q is given by,

$$= \text{CFM (Cubic Feet per Minute)} = [(2 \text{ x } A_2\text{- } a_2) \text{ x } L_2 \text{ x } C] / 1728$$

Where,
A_2 = Piston Area (Square Inches) = 1.95 Inch^2
a_2= Rod Area (Square Inches) = 0.27 Inch^2
L_2 = Stroke (Inches) = 3.94 Inch
C = Cycles per Minute = 5 (Assumed).
CFM = [(2 × 1.95 – 0.27) × 3.94 × 5] / 1728 = 0.04 ft^3/min or 1132674 mm^3/min or 0.0011 m^3/min.
Flow rate of each stroke Q_2 = 18877.9 mm^3/sec or 1.83 × 10^{-5} m^3/sec
Converting the flow rate from CFM (compressed air) to SCFM (free air) can be calculated as follows,

$$\text{SCFM} = \text{CFM} \times (P + 14.7) / 14.7$$

Where,
P = Supplied pressure in psi = 0.04 × (113.8 +14.7) / 14.7

$$SCFM = 0.35\ ft^3/min \text{ (for free air)}$$

So, the consumption rate of a 40 mm bore, 100 mm stroke cylinder operating 5 complete cycles per minute at supplied pressure of 8 kg /cm^2 is 0.35 SCFM (Standard Cubic Feet per Minute) of free air and 0.04 ft^3/min for compressed air.
Speed on the outward stroke= Q_2/A_2 = 18877.9/1256.63 = 15.02 mm/sec.
Speed of retraction = $Q_2 / (A_2 - a_2)$ =18877.9/1079.92 = 17.48 mm/sec
Power = $P_2 \times Q_2 = 1.01 \times 10^6 \times 1.83 \times 10^{-5}$= 18.48 watts.
The present work has selected base plate of thickness 14 mm.
Size= L 762 mm ×W 762 mm × T 14 mm.

Weight lifting capacity of self-guided smart chair system is up to 90 kg maximum. Self-guide smart chair system can lift chair up to 5.5 ft height.

Two battery of Voltage Rating = 12 VOLT and Current Rating = 7.3 AMP is used to drive two DC gear motor which will produce RPM 300 and speed of DC motor get reduced by voltage control method.

Provide comfort to access book within library especially for handicapped person.

Benefits of this self guided smart chair system are,

- Used compressed air which is easily available and eco-friendly.
- Easy to operate.
- Robust in design.
- Low maintenance.
- Simple in construction

VII. Conclusion

A library is organized for use and maintained by a public body, an institution, a corporation, or a private individual. The present work are implementing such an innovative system which can be operated by people within library to access book from heighted shelves which is known as self guide smart chair system.

Self guide smart chair system can be operated by user within library very conveniently. Two wheels are driven by DC motor chain drive which can be operated by battery through switch. Other two wheels are idler which will follow driving wheels. By operating switch user can operate and drive smart chair easily.

Upward and downward motion of chair is operated by pneumatic system. Compressed air pressure of 8 kg/cm2 is supplied to the pneumatic cylinder. Double acting pneumatic cylinder operated by hand operated switch which will move chair up and down. So user can easily reaches up to heighted shelves to access book.

Basic ergonomics are also considered while designing this system like side rack to the chair to place books, front wooden pad to hold book etc.

Design of includes base plate is done for a known application weight. Also double acting pneumatic cylinder design according to known application weight and height to be covered to access book from shelves. Model is fabricated as per design calculations. Motor has selected according to weight to be drive and as per application requirements. As per design calculations base plate of L 762 mm × W 762 mm of 14 mm thickness is used. And pneumatic cylinder of 600 mm stroke and 80 mm bore diameter is used.

Left and right movement of chair will be controlled by small pneumatic cylinder of 100 mm stroke and 40 mm bore attached to bottom of chair. Flow control valve is used to control air pressure.

This system will provide human comfort level within the library while selection of books by implementing pneumatic system.

Pneumatic system uses compressed air which is easily got available, cheap to prepare, efficient and cost effective system. Compressed air is supplied directly to the system through supply air tubes. Compressor can be located outside the library so noise gets reduced inside library. This self guided smart chair system can be very useful for handicapped person.

Further work in this self guide smart chair system includes pneumatic cylinder which can be replaced by telescopic cylinder. This will cover distance from lower level to higher very conveniently. In present work air is directly supplied to the pneumatic cylinder and required air pressure is obtained and controlled by flow control valve. Air receiver can be added to the system to maintain sufficient storage of air which will provide more flexibility to the system.

Acknowledgments

We would like to take this opportunity to express our deepest gratitude to all those who have support us and helped us to make this paper a reality.We are highly indebted to Prof. R. R. Gandhe for his guidance and constant supervision and also for his support in completing the paper.

In conclusion, we would like to thank our parents and colleagues for their kind co-operation and investing their time, and willingly helping us with their abilities to make this paper a reality.

REFERENCES

[1] Boateng, Henry; Agyemang, Franklin Gyamfi; and Dzandu, Michael Dzigbordi,"The Pros and Cons of Library Automation in a Resource Challenged Environment: A Case Study of KNUST Library" (2014). Library Philosophy and Practice (e-journal). Paper 1061.
[2] Ming-Hung Tsai, Chi-Neng Cheng, and Ming-Chang Shih. "Design And Control For The Pneumatic Cylinder Precision Positioning Under Vertical Loading", National Cheng Kung University Tainan.
[3] Yunxu SHI, Xiaoning LI and Yan TENG. "Research on Pneumatic Cylinder's Exhausted-Air Reclaiming Control Devices "International symposium on fluid power, November 7-10,2005.
[4] M. F. Rahmat, N. H Sunar and Sy Najib Sy Salim. "Review on Modeling and Controller Design in Pneumatic Actuator Control System", International journal on sensing and intelligent system vol. 4, no. 4, December2011.
[5] C.E. BRUBAKER," Wheelchair prescription-an analysis of factors that affect mobility and performance", Journal of Rehabilitation Research and Development Vol . 23 No. 4.Pages 19-26.
[6] BRUBAKER CE, MCLAURIN CA, MCCLAY IS," A Preliminary, June Analysis of Limb Geometry and EMG Activity for Five Seat Positions", Proceedings of the VIII Conference on Rehabilitation Technology, RESNA, 350 351, June 24-28, 1985.
[7] Kim, K., Ebert-Hamilton, S., and Reed, M., "Statistical Modeling of Automotive Seat Shapes," SAE Technical Paper 2016-01-1436, 2016, doi: 10.4271/2016-01-1436.
[8] J. L. Shearer, "Study of Pneumatic Process in the Continuous Control of Motion with Compressed Air," Transactions of the ASME, pp. 233-249, 1956.
[9] Du Jingmin, Fu Xiaoyun, Li Baoren. Experimental Research on High Precision Real-time Control of Air Temperature [J]. Chinese Hydraulic and Pneumatic, 2002,12: 19-20.
[10] N. Satyanarayana & Ch. Sambaiah, "Fatigue Analysis of Aluminum Alloy Wheel Under Radial Load" at International Journal of Mechanical and Industrial Engineering (IJMIE), ISSN No. 2231 –6477, Vol-2, Issue-1, 2012.
[11] BIFMA International, Ergonomics Guidelines for VDT (Video Display Terminal) Furniture Used in Office Workspaces. Document G1-2002. February 28, 2002.
[12] Kauzlarich, J. J., Thacker, J. G. & Ford, M. R. (1993). Electric wheelchair drive train efficiency. RESNA 1993. 310-312.
[13] Thacker, J.G., Sprigle, S.H. & Morris, B.O. (1994). Understanding the technology when selecting a wheelchair. Arlington, VA: RESNA Press.
[14] Brubaker, C.E. (1989). Wheelchair IV, Report of a conference on the state-of-the-art of powered wheelchair mobility, December 7-9, 1988. RESNA Press.
[15] Menka Dubey,"Speed Control of DC Motor," International journal of engineering science and research technology, vol 2, August, 2015.

All rights reserved by *www.ijirst.org*